C-21 FLEET: BASE OPTIMIZATION

GRADUATE RESEARCH PAPER

June 2015

Rebecca A. Wyffels, Major, USAF

AFIT-ENS-GRP-15-J-024

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT-ENS-GRP-15-J-024

C-21 FLEET: BASE OPTIMIZATION

GRADUATE RESEARCH PAPER

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Mobility Logistics

Rebecca A. Wyffels, BS, MS

Major, USAF

June 2015

AFIT-ENS-GRP-15-J-024

C-21 FLEET: BASE OPTIMIZATION

Rebecca A. Wyffels, BS, MS
Major, USAF

Committee Membership:

Dr. Darryl K. Ahner
Chair

Abstract

This research reveals the optimal use of the C-21 in support of Distinguished Visitor (DV) transport of all military service branches and the highest ranking civilians in our nation is beneficial in many ways. Optimal basing of these assets reduces the flight hours over the positioning legs of the missions resulting in a reduction of spending, an increase in flexibility and a more effective use of the time of the passengers, the C-21 crew and maintenance. This research project analyzed over 1000 flights on over 350 missions conducted between January 1 and December 31, 2014 to capture a recent mission database. The two geographically separated units with twelve total assigned C-21s are currently located at Andrews Air Force Base (AFB), Maryland and Scott AFB, Illinois. The missions flown from these bases in the last calendar year were compared against an optimal solution minimizing travel distance to determine the best allocation of the assets.

Based upon the analysis of the 2014 mission data, the eight C-21 assets currently supporting the operational support airlift and Southern Command missions should be divided evenly between Scott and Andrews AFBs. If an additional asset, currently assigned to the C-21 formal training unit or Southwest Asia were dedicated to the DV transport mission, then the optimal basing ratio would apply to nine aircraft and would result in utilizing the additional asset from Scott AFB where it is currently assigned. Operating the 2014 mission set optimally, would have resulted in 299 fewer flight hours flown, realizing a savings of $213,187 and a 23 minute daily increase of availability for DV flexibility.

This research project is dedicated to my husband, my daughter and my son. Thank you for the love and the support throughout this year.

Acknowledgments

I would like to thank my advisor, Dr. Darryl Ahner. His insight, his patience and his genuine interest in his students aided my completion of not only this Graduate Research Project, but the Advanced Studies of Air Mobility (ASAM) Program. My sponsor, Col Jeanette Voigt, a former ASAM graduate and my former squadron commander, thank you for the opportunity to make an impact with this project and I hope to inspire an ASAM student someday, just as you have. Additionally, I would like to thank Capt Chris Dubois, 458 AS/CSS for supplying over 1000 flights of data from multiple sources on my behalf. Rebecca A. Wyffels

Table of Contents

Page

List of Figures

List of Tables

List of Equations

C-21 FLEET: BASE OPTIMIZATION

I. Introduction

General Issue

The Air Mobility Command (AMC) C-21 fleet is currently spread between two bases: Scott Air Force Base (AFB) in Illinois and Andrews AFB in Maryland, just outside Washington D.C. The bases are geographically separated units under the 375th Operations Group (OG) at Scott AFB. The C-21 delivers the top ranking generals of all military services and congressmen in the continental United States to their business destinations. The C-21 is also used to season pilots through the experience of a wide variety of airports, multiple training hours, and building airmanship on an airframe that operates on a FY14 flight hour cost of $713 which is a fraction of the cost of a large cargo aircraft such as a C-17 whose flight hour cost in FY14 was $11,398.68. See Appendix A. The C-21 is also used in humanitarian relief efforts such as Hurricane Katrina and aeromedical evacuation missions such as moving injured soldiers. The decision of how many planes should be stationed at each location is of great relevance. The optimal solution, and likewise defining an objective to optimize, in these times of fiscal restraint and manpower drawdown has to be determined to fulfill the needs of effectiveness and flexibility to achieve the most value for our efforts.

Problem Statement

Dwindling budgetary resources and manpower force us to find the optimal basing strategy for the C-21s in the AMC fleet. Reducing costs of money and time as well as increasing our customer value: by providing flexible and available service are associated

with efficiency of operation. Improving this efficiency of this operation can be achieved by determining basing decisions and follow-on actions of assignment of assets that can be easily implemented by Air Force leadership, as the aircraft belong to the same group and wing commander.

Research Objectives/Questions/Hypotheses

Objectives

The goal of this research is to analyze the use of the C-21 in Distinguished Visitor (DV) transport and Southern Command (SOUTHCOM) transport, to establish the optimal number of C-21s at two bases: Scott and Andrews AFBs. Reaching the most efficient and effective basing decision for the twelve C-21s in AMC will result in costs savings and flight hours directly affecting the budget in a fiscally-strained environment. This benefits both the taxpayer and the Air Force as it seeks to attain the budget limitations set by Congress. The effectiveness of the operational support airlift (OSA) assets is increased as flexibility and availability is increased for the passenger with the reduction of flight hours as well. Lastly, the goal of optimization is based on modeling the prior year's flights carrying DVs as passengers, determining the origin and destinations of the C-21s that produce a minimum distance travelled, and then applying that ratio of optimal flights out of each base to the asset allocation of the C-21s.

Research Questions

How many assets in support of OSA missions need to be assigned to either base?
Is acquisition of an asset from the C-21 FTU at Scott AFB or dual use of the assets, increasing our mission availability likely?

Is it likely that the C-21s currently supporting Southwest Asian could be utilized in support of OSA in the Continental United States in the future?
Is the historical data derived from the calendar year 2014 (CY14) mission set a good representation of the future customers and routes?
Should the routes be analyzed as missions or separate active legs?
Which unit of measure should be used: flight time or miles?
How is the basing proposal affected by an elimination or reduction of one of the types of current missions: the Office of the Assistant Vice Chief of Staff/Special Air Missions (CVAM), Joint Operational Support Airlift Center (JOSAC) or Southern Command (SOUTHCOM) missions?

Hypotheses

An even split of aircraft between Andrews and Scott AFBs will produce the most advantageous ratio of assets for mission execution. In the case of an odd number of assets, the majority of aircraft should be located at Scott AFB to achieve the greatest value per asset.

Research Focus

This Graduate Research Project will propose the optimal assignment of either the current eight or hypothetical nine C-21s at their current locations: Scott and Andrews AFBs. An area of further research should include the entire fleet of differing types of aircraft that make up the CVAM assets as well as their origins. The model should be run against all users and routes flown daily to optimize the entire program.

Assumptions/Limitations

The assumption that the CY14 CVAM, JOSAC and SOUTHCOM data will be a predictive forecast of the future requests for and use of DV airlift. If there is a major shift

in the positioning of high level generals in any of the services, then there may be a shift in the origin and destination of the users. Further, should more congressmen use DV airlift, then again the route demand will shift.

Implications

The impact of this research will prevent the Air Force from overspending time and money while conducting the mission of transporting its highest officials. If the proposal results in a large shift in aircraft between the bases, then the possibility of closing of an entire squadron could be considered once fixed maintenance costs and manning are taken into consideration.

The logistical impact of this study on the body of knowledge is not limited to same-type fleet issues but can be applied to the Air Force fleet-wide. The spreadsheet model allows for various inputs of assets, origins, and city-pairs to optimize basing based on minimum distance travelled.

Sponsor

Col Jeanette Voigt, 375th Operations Group Commander, Scott AFB.
Included under her command are the 457th and 458th Squadrons at Scott AFB and Andrews AFB, executing the support missions for OSA and Southwest Asia as well as the training mission at the C-21 FTU at Scott AFB.

II. Literature Review

In Depth/Relevant

According to Otley, in his 2011 article "Jet Powered" in *Business Traveller*, there are ten times as many airports that the C-21 can go into than the larger jetliners. The large data set of over 400 city-pairs of active legs of the C-21 reflects this. This makes the business jet sized aircraft incredibly flexible for transport of passengers into and out of airports in much closer proximity to their end destinations than many large hubs. This is favorable due to a reduction in travel time on the ground both before the flight and after.

Additionally, the amount of time needed for arrival and baggage handling is cut significantly when traveling by business jet. Showing up half an hour prior to takeoff time and being in a taxi within fifteen minutes of landing is not uncommon. The C-21, with access to almost all military runways, is able to pick up a DV passenger and deliver him or her off at the next military base avoiding the costs and commute time of taxis to a major hub by using base transportation as well. The additional time of check-in, layovers for a few hours, and the additional commute and waiting for baggage on the back half are eliminated making for a pleasant trip that eliminates a lot of time spent gaining nothing.

The range in available origins and destinations for the C-21 is very large. Within CONUS, the C-21 can go coast to coast with one quick stop for fuel and stretch of legs. It can cruise over 500 miles per hours and its range is over 2,000 miles. For example, with a comfort break of 30 minutes and a ground refueling, the C-21 can go from

Andrews AFB in the National Capital Region to Travis AFB in northern California, 2100 nautical miles away in approximately 6 and a half hours. The C-21 has often delivered DVs to destinations with runways unsuitable for large aircraft, making it extremely attractive to those traveling to a destination more than an hour away from a commercial hub or AFB where a small airport is convenient.

The amount of time a top executive from a company or a leader in our armed services saves in travel, has corresponding cost savings associated with it. Executives earning over $250,000 each year make approximately $1,000 every work day. This sum is less than a three star general and a lieutenant colonel aid's base salary. (Airforce.com) Therefore, even part of a day spent commuting that can be limited, has economic value added. While commuting and waiting are not as large barriers to getting work done as they used to be due to advances in technology, they are still burdensome.

With multiple destinations, and some of them within a few miles of each other, one way to model movement is using the idea of sectors such as Klincewincz (1990) suggests in his warehouse delivery model. See Figure 1. The C-21 destinations could be simplified and the flight times, if not already existent could be imputed using an equation averaging distances to locations in the same region and summing the frequency of trips to that region. This method is less accurate for overall mileage and flight hours flown, but has advantages is its ability to be user friendly. It is also useful in linear programming with multiple cargo loads and constraints on each leg, whereas the C-21 is dealing largely with a load of up to four passengers and point to point to point delivery versus carrying cargo through or unloading it for storage as inventory to be held at the cheapest cost.

This model would also be more advantageous for a regional or major airline in moving passengers through a hub system.

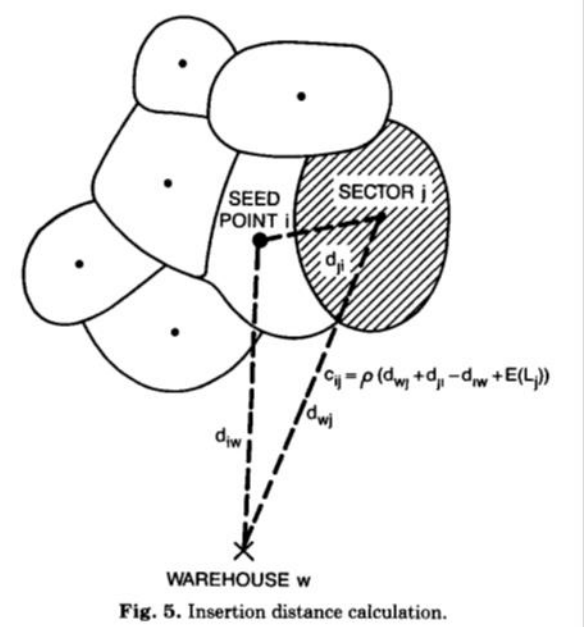


Fig. 5. Insertion distance calculation.

Figure 1. Insertion Distance Calculation

Another set of fleet optimization equations is used by Martin in 2003 in "Optimizing On-Demand Aircraft Schedules for Fractional Aircraft Operators." His assumption of crew pairing with aircraft is extremely advantageous when the primary hours of operation are 7am to 7pm, precisely the hours the C-21 is utilized, but his methodology does not apply to the C-21 fleet due to the lack of crew pairing and returning back to origin almost every mission. The C-21 rarely stays overnight away from maintenance and is scheduled out of its origin. This is largely due to two factors: the C-21 has only two locations versus seven just a decade ago with maintenance available and the fleet is a fraction of what it was, reducing flexibility to pair crews to

aircraft. His equations assess various factors of route optimization that would be beneficial to use should the Air Force return to a larger number of business jet sized aircraft with multiple bases.

In Torczynski's 2014 paper *Preserving Readiness: A Domestic Channel Solution to Cost-Effective Mobility Pilot Experiencing* he points to the economy of the C-21 or a like-sized aircraft, in building flying hours for newly graduated pilots from Specialized Undergraduate Pilot Training. We have either the C-21s recently retired or the fleet of T-1s that could be utilized in this manner. He argues that pilot seasoning and preparation could be done in an aircraft with a much more inexpensive flight hour such as the C-21 at $732 per hour versus a Mobility Air Force (MAF) asset at over $10,000 per hour. The reduction of the costs of experiencing pilots for 500 to 1000 hours, which is a necessity in the times of the Transportation Working Capital Fund (TWCF) drawdown, delivers DVs at the same time, while eliminating the cost of commercial flight tickets and increasing effectiveness of door to door service, and ultimately avoids costs in the millions.

In 1996, "Maintenance and Crew Considerations in Fleet Assignment," Clarke addresses the cost issue that hits home with the Air Force and this research, minimizing the operating costs. He transforms the optimization equation into a real-life applicable answer by considering maintenance personnel and checks, crew duty time, turn times, flight schedule, and consistency of the schedule the assumptions are based on. His "whole system" approach takes the larger look and does not focus on just one metric: the flight hour. He does fall short in, not mentioning fixed costs such as the building holding the maintenance or squadron personnel, nor does he account for the electricity and

upkeep of ground structures or additional costs such as crew temporary duties when staying overnight away from home station.

Theoretical Model

The warehouse model offers the idea of sectors, as well as the need for the mode of transportation to return to its original destination, which is does match the current situation, but the air allows for different lanes to each destination, and although there are approach and departure corridors and arrival and departure procedures that route traffic in and out of very busy airspace, the application of a main thruway such as a freeway or tunnel, is not quite applicable. Additionally, the traffic, although congested in the air, is very predictable compared to a traffic accident on the single route to a sector. When the ability existed to analyze in depth each and every single city-pair, the analysis is more exact and credible, therefore, it was completed in that manner.

Martin's equations applied to the C-21 scenario a decade ago, when the fleet had multiple hubs around the CONUS, multiple flights and the fleet size of aircraft dedicated to the OSA mission was seven times what it is today. This complex problem has been simplified by comparing only two bases, which the aircraft largely depart and return to at the beginning and end of each mission.

Clarke's model takes into consideration additional costs and contingencies, but again, needs to be expanded for a more accurate assessment. In this research, with fixed costs in place, the focus on the flight hour as a final metric of both cost and time savings, it can be said that fewer flight hours result in less frequent maintenance checks and maintenance overall, without a defined amount.

III. Methodology

Chapter Overview

This chapter details the methodology used in this research and describes the spreadsheet model that was utilized in determining the optimal basing ratio based on efficiency and effectiveness of the C-21 assets assigned to Scott and Andrews AFBs in support of the OSA mission. The data sources, along with the assumptions behind and limitations of the spreadsheet model of the analysis are addressed as well.

Data Sources

The data supplied by 375th OG came in two forms: an interview on the utility of the assets and manning assigned to Scott and Andrews AFBs and spreadsheet data.

The interview established that of the twelve assets assigned to the 375 OG, two aircraft were utilized in Southwest Asia (SWA) and not for Continental United States (CONUS) missions. Two additional assets were considered training aircraft for use by the C-21 FTU at Scott AFB daily. The remaining eight assets were assigned equally, four to Scott AFB and four to Andrews AFB, a geographically separated unit for the OSA mission. Currently, the 375th OG is available to support four missions total for CVAM and JOSAC daily Monday through Friday. Additionally, two missions are supported Saturday and Sunday, split evenly between the bases. The SOUTHCOM mission is supported when requested, approximately once a week by either base. Scott has the ability to utilize the aircraft assigned for training at the C-21 FTU in support of OSA missions should the OSA assigned assets at Scott AFB not be available or the manning

that would have flown a training mission needs to be used for the OSA mission. This is not planned or dedicated in this manner, it is a failsafe and utilized as such.

Additionally, Scott AFB has the squadron assigned personnel, the operations group and wing personnel that are attached as fliers and the FTU instructors to draw from for manning. This compares to Andrews AFB, which currently has a waiver to increase manning so that all squadron required duties can be fulfilled as well as the mission flown. This data is not considered in the base optimization, but reflects on the increased flexibility of Scott AFB currently. Andrews AFB, needs an increase in manning now, but would need a further increase with additional assets to operate the optimal basing resolution.

For the use in the application to the basing proposal, both eight and nine assets were considered due to a few assumptions: the Scott formal training mission flown for a few hours daily by both jets, could be flown by one jet as a morning mission and afternoon mission or on the weekends, freeing up another jet for OSA support, which as stated above is a fluid process already in place. Additionally, the SWA aircraft mission could lower its requirement to one aircraft or be supported by a different asset, therefore increasing the CONUS assets available. The model is flexible in application to any number of aircraft assigned, as the fleet of C-21s has seen changes in size and allocation multiple times over the last two decades.

The spreadsheet data has three sources: CVAM, SOUTHCOM, and JOSAC. This data included: mission number, the DV passenger title, the route flown including positioning legs, active legs and de-positioning legs; and the flight time. The definition

of an active leg is when the aircraft carried a DV passenger on board. The data set had 774 active flight legs flown in CY14.

The capabilities of the C-21 were also critical in analyzing data for errors such as an incorrect data entry in flight hours, well-exceeding the endurance and range capacity of the C-21 or the speed. The C-21 carries eight passengers with a range of 2,000 miles. A flight time greater than five hours was flagged and an imputed flight time replaced it. This occurred on five flights. For active legs, defined by a city pair, such as KOFF-KBLV, Offutt AFB to Scott AFB, where there were multiple flights, the flight time was an average of all flights and rounded to the nearest tenth. To determine the city-pairs' optimization, a mission started out as a flight out of Andrews AFB, then the active city-pair leg, then a return to Andrews AFB. Then a mission starting with a flight out of Scott AFB, then the active city-pair leg, then a return to Scott AFB. The missions' total distance travelled was compared to determine the most efficient mission. When the flight time was compared, and the flight time did not exist because that leg or city-pair was not flown in the last year, then a flight time was imputed.

To impute the flight time, the distance in nautical miles between beginning and end destination was determined using www.distancetofrom.net, an online flight calculator for 769 active legs. The flight times for 769 were summed. The C-21 approach and landing is assumed to take 15 minutes (or .3 hr) every mission. Therefore, to attain the average speed of the C-21 on OSA missions in nautical miles per hour, the total approach and landing time for all missions needed to be subtracted from the total flight time for all missions. The remaining flight time divided by the total miles for all missions resulted in

395 nautical miles per hour. See Equation 1. This equation was applied to replace the five erroneous flight times as well.

((Nautical Miles)/ (395 NM/Hr)) + .3 = Flight Hours

Equation 1. Nautical Miles to Flight Hours

Data Analysis

The spreadsheet model used the supplied spreadsheet data and organized the origin and destination of the active legs into city-pairs and frequency of use. The data remained filtered into type for analysis, this allowed for analysis of the data by type and accounts for basing decisions should the C-21 no longer support the CVAM, JOSAC or SOUTHCOM mission in the future and displays the impact of the type of mission on the basing decision. The positioning legs and de-positioning legs were not utilized, but the origin of the aircraft for each active legs was later used in the comparison of the actual aircraft origin and the optimal aircraft origin to determine the cost savings that would have occurred if flown optimally in CY14. Every active leg on every mission flown in CY14 by C-21s serving in the OSA or SOUTHCOM support capacity in CONUS was included. The distance from Scott AFB to the origin and destination was determined in nautical miles using the distance calculator. Then the process was repeated for Andrews AFB.

The total mission distance in nautical miles from Scott AFB including the active leg and back to Scott AFB, was compared to the same roundtrip out of Andrews AFB. The minimum distance travelled determined the optimal solution for each active leg. The

ratio of optimal origin to the total missions from each of the two bases determines the asset basing proposal.

The optimal solution was based on efficiency and effectiveness. There are two types of efficiency displayed: cost avoidance and time. The Air Force achieves the same mission for fewer flight hours, which is $713 per hour when the price of fuel is $3.62. See Appendix A. The other savings is the time. "Doing more with less" is achieved by giving back time to the pilots of the aircraft to accomplish other duties. It gives time back to maintenance to fix any last minute items. It gives back time to the customer and allows for flexibility in the case of a meeting gone long or traffic, transiting from the National Capital Region to Andrews AFB for example, or for more work to be done at the office. Accomplishing the same value-added mission and eliminating waste, is a common theme in LEAN theory, also part of Air Force Smart Operations for the 21st Century program. By optimizing the basing, the waste is eliminated in this process. Effectiveness is achieved by increased flexibility and availability. A jet on the ground is available for an additional mission or has a more flexible schedule to accommodate the user as well as the flexibility to meet demands when delays occur such as weather, maintenance, or air traffic control.

The cost avoidance is considered by flight hour savings. When the basing optimization results in a large change in aircraft at one location, then the maintenance and manning changes need to be considered. This research does not account for those costs. Additionally, the manning at both Scott AFB and Andrews AFB needs to be sufficient to fly the OSA mission, train, and fulfill the duties within the squadron, group, wing and FTU. Scott has more flexibility in manning, in that the group and wing allocations are

located there as well as the FTU. It is critical that Andrews AFB has the manning to support the optimal basing proposal to fulfill these savings.

There are multiple limitations of the CY14 data. The data set utilized was recent history, therefore reflected the fulfilled requests of the DVs and current demands. Due to the drawdown and lack of manning in the past year, there were fewer missions flown and therefore, many unfulfilled requests that were not represented. Further, the missions flown are somewhat determined by the origin: Scott AFB or Andrews AFB, because the mission must be completed in the duty day. Therefore, the current basing affects the mission flown data set which is used to determine optimal basing.

Summary

The spreadsheet model determined the optimal basing proposals based on eight and nine aircraft based on efficiency and effectiveness of the C-21 assets assigned to Scott and Andrews AFBs in support of the OSA mission. The interview and spreadsheet data sources, along with some assumptions of historical data being representative of the future demand and a few erroneous data entries that needed to be corrected with imputed data are acknowledged. The equations and spreadsheet model can be utilized with other USAF assets of any number with multiple city pairs and origins.

IV. Analysis and Results

Chapter Overview

Using a spreadsheet model to analyze over 1000 OSA flights on over 350 missions in CY14, in order to determine the optimal basing of eight C-21s assigned to two bases, Scott and Andrews AFB, there are multiple areas of areas of interest in the results. The number of most efficient missions from each base, determined by the fewest miles flown roundtrip: departing out of one of the two bases, picking up and delivering a DV to a destination and returning to that base, varied by type of mission. The assignment of eight or nine C-21 assets to either Scott or Andrews AFB is derived by accumulating the number of most efficient missions from all three types of missions: Joint Operational Support Airlift Center (JOSAC), Office of the Assistant Vice Chief of Staff/Special Air Missions (CVAM), and Southern Command (SOUTHCOM), and comparing the two bases in a ratio. The delegation of assets would change if there were a loss or a reduction of one type of OSA mission. The missions flown last year, reflect to some degree, the limited assets available and not necessarily the current customer demand with the associated four C-21 missions flown daily in CY14. The most common routes flown annually do not drive the basing optimization, eliminating one of those routes due to a base closure or other circumstance, would not alter the basing assignment of the C-21 assets. The majority of routes are flown less than five times annually. Finally, the results reveal the savings when optimally executed. The fewer miles flown, results in fewer flight hours which is time saved as well as monetary savings.

Results of Spreadsheet Model

The first analysis conducted was the number of missions flown most efficiently out of Andrews and Scott AFBs. For each base, the total nautical miles flown on a mission were determined from the origin, on an active leg, and then returning to the origin. For example, if a DV were travelling from Kirtland AFB, NM and Forbes Field, KS, and the C-21 started and ended the day at Andrews AFB, the miles from Andrews AFB to Kirtland AFB, from Kirtland AFB to Forbes Field, and Forbes Field to Andrews AFB give a total mileage of 2,891 nm. Then the roundtrip mileage is compared to a flight starting and ending at Scott AFB. If the same active leg was flown, but started and ended at Scott AFB, then the mileage would be 1,679 nm. In this scenario, the most efficient mission is out of Scott AFB because it is fewer total miles. For missions that were the same number of miles out of either base, such as active legs where a DV is traveling from Andrews to Scott AFB or Scott AFB to Andrews AFB, the missions were not counted when comparing optimization. The percentage of efficient missions out of a base was determined by dividing the number of missions most efficiently flown out of that base by the total missions (minus the evenly efficient missions). For example, Scott AFB is most efficient on 378 missions out of 733 missions, which results in a .52 ratio or 52%. Therefore, based on this data, the optimal ratio of .52 can be used later to assign aircraft to bases with several assumptions.

When considering the logistics of operating two separate bases, the customer service priorities and the additional costs need to be weighed against each other. The basing ratio provides optimization based on flight hours, but the infrastructure, the maintenance, the additional manning for the squadron, are all costs. The availability and

the increased flexibility of two bases need to be weighed against those costs. In the case of a 52% ratio, the efficient missions are fairly evenly distributed and the savings through consolidation would impact mission effectiveness. This model is based on one asset, and the Air Force savings needs to be realized over the entire system. The Air Force may be sub-optimizing itself by cutting C-21 bases, assets, and hours to reflect savings that are at a low flying-hour-rate. See Appendix A.

Another way to look at this data is by mission type. Just as the basing of C-21s has drawn down in the last few years from eight bases to two, and the assets to about a quarter of the original buy, the missions that the C-21 have supported have also changed. Looking at the optimal basing ratios of each mission type is relevant, because the constantly changing Air Force may emphasize SOUTHCOM travel, for example, and reduce the JOSAC support for the next several years. Therefore, the mission optimal ratios can be used to determine the basing assignment most fitting to the missions flown proportionally. The minimum distance travelled on each type of OSA mission: CVAM, JOSAC and SOUTHCOM, was totaled and compared between Scott and Andrews AFB. Again, repeating the formula for the optimal ratio: dividing the most efficient missions from each base, by the total number of missions flown less the missions that were the same, the percentage of optimal missions is derived. As seen in Figure 2, in totality, Andrews and Scott AFB do not differ by a large amount, Scott is only 23 of 733 missions more optimally chosen. The CVAM mission is similar to the overall results, in that Scott AFB has a slight majority of efficient flights over Andrews AFB. The JOSAC mission is more disparate and more heavily weighs towards Scott AFB having more aircraft. This is of note, because just a decade ago, the SOUTHCOM mission and CVAM mission were

almost non-existent and the C-21 fleet supported primarily JOSAC. If this were the case last year, then the majority of aircraft would optimally be assigned to Scott AFB. Finally, almost all SOUTHCOM missions can be flown out of Andrews AFB optimally. There are fewer flights dedicated to SOUTHCOM, but again, this could change. Figure 2 visually displays the majority of flights supporting CVAM, followed by a smaller amount in JOSAC and then the least supporting SOUTHCOM.

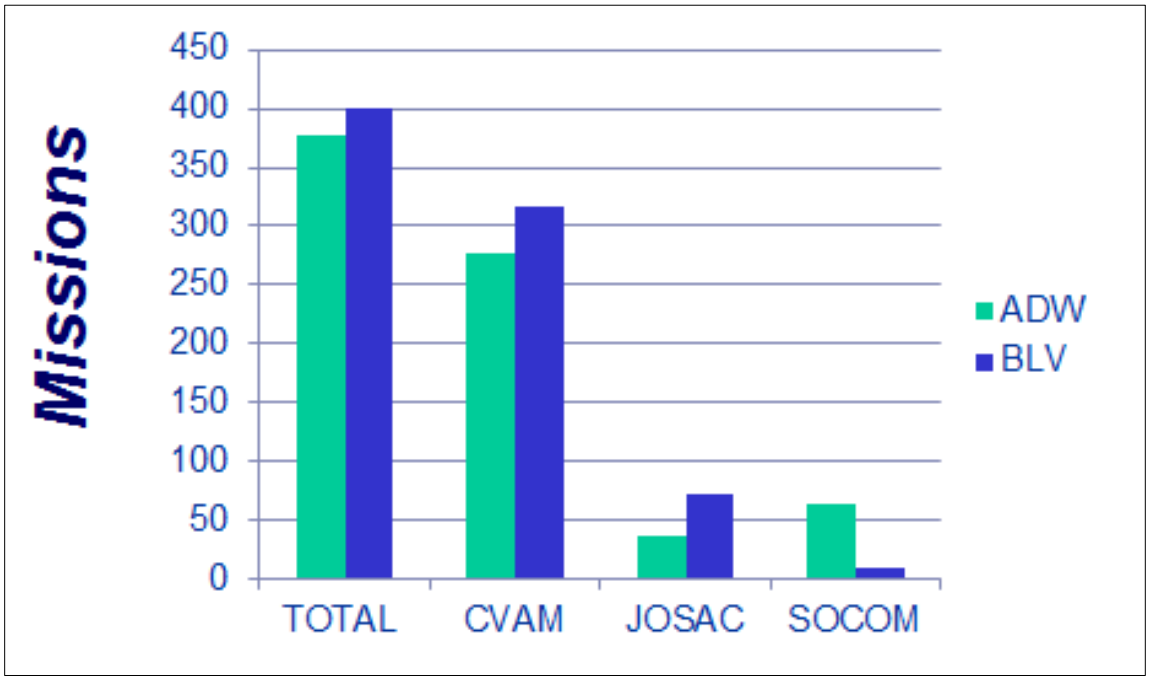


Figure 2. Number of Most Efficient Missions by Base and Mission Type

Dividing the number of missions most efficiently flown by the total number of missions flown less the missions that were even, the percentage of missions is derived. As in Figure 2 above, Table 1 below, presents the close margin of only 4% difference in optimal missions between Andrews and Scott AFB. CVAM alone, is within 8% as well.

JOSAC has a 33% difference, and even further separated is SOUTHCOM with a 72% difference in the optimal basing solution.

Table 1. Percentage and Number of Most Efficient Missions by Base and Mission

	Andrews AFB	Scott AFB	Andrews AFB	Scott AFB
TOTAL	48%	52%	355	378
CVAM ONLY	46%	54%	255	295
JOSAC ONLY	33%	67%	36	73
SOUTHCOM ONLY	86%	14%	64	10

The mission data in CY14 used was limited to missions that the 375th OG could support, which is not the same as the current state. According to the 458th Airlift Squadron in the 375 OG, the drawdown of manning at Andrews AFB, led to insufficient resources to execute missions for a time in CY14. Therefore, if unable to fly missions out of Andrews, then the only missions filled had to launch and return to Scott AFB within a duty day, which would drive the data to represent those missions within a certain proximity to Scott AFB and not necessarily the missions with the highest priority. This proximity to Scott AFB has some overlap with Andrews AFB, but the circles are not concentric and favor Scott in this analysis as portrayed in Figure 3 below. Therefore, it would be reasonable to assume the data for optimization would favor Scott AFB, if all else were even. This same reasoning may affect the optimal basing proposal as well. If assets are available out of a base, then the missions flown will likely be most efficient out of that base. Therefore, it is hard to distinguish between the requests driving the basing or the basing driving the missions filled when analyzing historical data. The circles

represent the missions that could be flown when a DV is not starting or ending at the origin, for example, Andrews AFB or Scott AFB. There is an assumed 30 minute stop to pick up the DV and a 30 minute stop when delivering him before returning to origin. The diameters of the circles are larger when the DV is at one of the origins, or the active leg is in a straight line to and from a base, but that does not reflect the vast majority of missions.

Figure 3. Typical Duty Day Range Circles, Scott AFB, IL and Andrews AFB, MD

The number of missions flown during the year also affects the data. Currently, four missions are flown Monday through Friday, and an additional two on Saturday and Sunday. Throughout CY14, due to resource limitations, often only two missions were filled per day through the week and one daily on the weekends. The remaining unfilled requests did not have representation in CY14 data. These unfilled missions would not likely reflect vast changes in the city-pairs, because there are already over 400

combinations, but could reflect a different optimization percentage if the preponderance of the missions would have flown out Andrews AFB, for example. Additionally, according to the 375th OG, SOUTHCOM missions have been supported after the CVAM missions have been dedicated. Should the priority or amount of these missions increase, especially because they largely favor Andrews AFB, then the basing ratio could shift. Below, in Figure 4, reflects the percentage of each type of support mission flown.

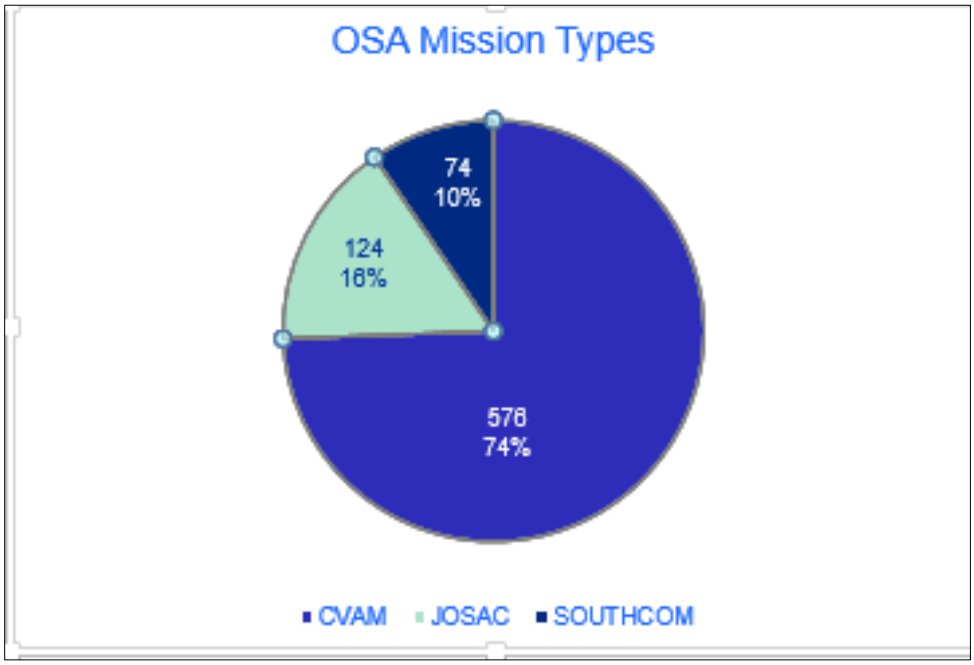


Figure 4. OSA Mission Types

To arrive at the delegation of assets, the ratio or percentages of the total missions flown that were displayed in Table 1 earlier, can be applied to the available eight or nine C-21 assets and determine the delegation of assets as seen below in Table 2. Currently, there are eight assets dedicated to the support of JOSAC, CVAM and SOUTHCOM missions. If one of the two assets in Southwest Asia (SWA) or one of the assets assigned to the formal training unit (FTU) were to be used in support of these missions, then the

assets would increase to nine. Each type of mission is displayed if it stood alone and asset delegation were based solely on it. In the following paragraphs, the effects of one type disappearing is addressed.

Table 2. Delegation of Assets

	Aircraft	Andrews AFB	Scott AFB
TOTAL	8	4	4
	9	4	5
CVAM ONLY	8	4	4
	9	4	5
JOSAC ONLY	8	3	5
	9	3	6
SOUTHCOM ONLY	8	7	1
	9	8	1

In 2006, Andrews AFB did not support CVAM or SOUTHCOM regularly. JOSAC was almost completely the sole mission supported. Therefore, in a few years, missions can change dramatically within a squadron. The impact of a decision to no longer support the CVAM or JOSAC missions or a reduction in the percentage of missions of these types, could lead to a redistribution of the assets. In two scenarios, more assets assigned to Andrews AFB are favored, the other scenario would not change the base optimization. The impact of no longer supporting the SOUTHCOM mission has no impact on the allocation suggested in the results. The loss of the JOSAC mission or CVAM mission results in the allocation of the majority of assets to Andrews AFB. Although, this may seem unlikely that the small number, 74 SOUTHCOM missions, making up only ten percent of all missions currently, could have a large impact on basing, it is due to the large percentage of the missions optimized out of Andrews AFB. Figure 4 depicts that it is deceiving visually, the power on the basing ratio the

SOUTHCOM mission has. Due to the fact that it is 86% optimally favoring Andrews, drives the basing decision towards Andrews AFB with the withdrawal of one of the other missions. Figure 5 and Table 3 depict these results.

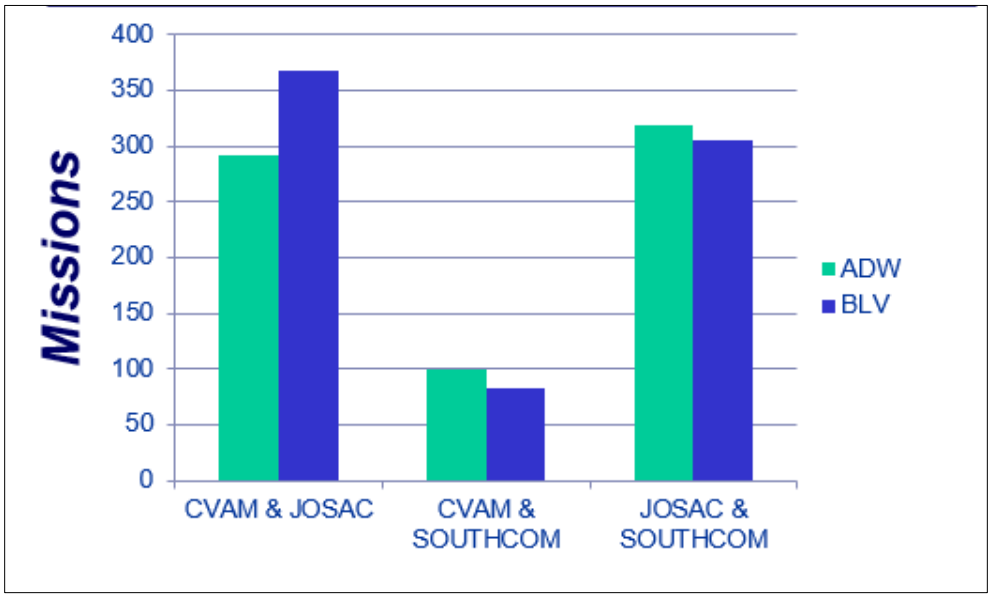


Figure 5. Number of Most Efficient Missions by Base, Minus a Mission Type

Table 3. Percent of Efficient Missions and Base Assignment

	Aircraft	Andrews AFB	Scott AFB	Andrews AFB	Scott AFB
TOTAL	8	4	4	48%	52%
	9	4	5		
CVAM & JOSAC	8	4	4	44%	56%
	9	4	5		
CVAM & SOUTHCOM	8	4	4	51%	49%
	9	5	4		
JOSAC & SOUTHCOM	8	4	4	55%	45%
	9	5	4		

Highlighted in red in Table 3 is the addition of an asset to Andrews AFB when either the JOSAC or CVAM mission are eliminated.

Another aspect of the results is the lack of impact on the overall basing of the most frequently flown missions. The OSA mission is dynamic and the origin and destinations of the active legs are multiple. Of the 774 active legs, the over 400 city-pairs were developed and only seven were flown more than nine times as seen in Table 4. At most, an active leg on a city-pair was flown 24 times, which represents 3% of the total active legs. Together, the seven legs represent 15% of the total active legs. Further, 80% of active legs were executed only once last year and 85% fewer than five times in CY14. The impact of a loss of any of these missions on the delegation of assets as part of the C-21 airlift network is negligible due to many factors: the set of frequently flown city-pairs all favor Andrews AFB with the exception of the city-pairs between Andrews AFB to Scott AFB where they are evenly optimal from either base. Therefore, the ratio would continue to favor Scott AFB, but not by a large enough margin to justify another asset assigned. Additionally, the Miami (MIA) and Guantanamo Bay (MUGM) city-pairs are largely representative of SOUTHCOM and as noted above, the removal of the SOUTHCOM mission would not change the current overall basing ratio.

Table 4. Most Commonly Flown Active Legs

Active Legs	Times Flown	% Total
ADW-BAD	12	2%
ADW-BLV	13	2%
ADW-FFO	17	2%
BLV-ADW	11	1%
FFO-ADW	18	2%
MIA-MUGM	24	3%
MUGM-MIA	23	3%
Total Legs	118	15%

The last analysis compared the distances of the optimally flown active legs to the actual active legs flown during CY14. The ratio of the difference between optimal and actual nautical miles, to actual nautical miles represents the proportion of savings. The nautical miles flown from actual origins is 1,463,646. If flown from the optimal bases, 153,078 fewer nautical miles would have been flown. This ratio of .1046 is approximately a ten percent savings in miles. The sum of the flight time on all three types of missions: JOSAC (388.9 hours), CVAM (2233.5) and SOUTHCOM (230.9) missions in CY14 is 2,853.3 hours. See Table 5 below for flight hours. Multiplying the savings ratio .1046 by the 2,853.3 hours results in 299 hours that could have been avoided. Had these missions been flown out of the optimal base, it would have resulted in savings of $213,187 based on a C-21 flight hour cost of $732 in FY14. See Appendix A and Equation 2 below. Additionally, by flying approximately ten percent fewer nautical miles every mission, about 23 more minutes of flexibility for the customer is available on each mission.

Table 5. Total Hours for C-21s by Mission Type

Date	SCOM	CVAM	Other	FCF	FTU	AE	SWA	Trng	JOSAC	Total
14-Jan	0	167.8	0	3.8	30.9	18.3	121	95.6	99.8	537.2
14-Feb	9.4	244.7	0	0	0	5.7	120.3	88.2	57.8	526.1
14-Mar	56.7	199.3	0	0	74.9	7.2	88.6	98	85.8	610.5
14-Apr	6.2	217.6	0	0	6.4	22.8	76	163.2	7.7	499.9
14-May	0	195	0	0	60.7	41.8	47.9	62.4	13.1	420.9
14-Jun	50.1	141.6	0	0	33.2	0	39.9	77.3	16.1	358.2
14-Jul	29.2	165.3	0	0	106.9	0	70	87.9	0	459.3
14-Aug	35.5	205.3	0	0	0	0	94.8	64.1	3.7	403.4
14-Sep	24.1	181.6	0	0	61.6	0	47.8	55.1	18.9	389.1
14-Oct	11.6	209.1	0	0	41.7	0	84.8	110.2	16.6	474
14-Nov	8.1	170.9	4	1.9	81.5	0	95.7	78.3	8.8	449.2
14-Dec	0	135.3	0	0	0	0	55.5	111.8	60.6	363.2
	230.9	2233.5	4	5.7	497.8	95.8	942.3	1092.1	388.9	5491

Actual Miles Flown - Optimal Miles Flown = Excess Mileage
Excess Mileage/Total Mileage = Ratio of Excess in System
Ratio x Hours Flown= Flight Hours Saved
Flight Hours Saved x Cost of Flight Hr = Dollars Saved

Equation 2. Excess Mileage to Dollars Saved

Summary

There are more missions flown efficiently out of Scott AFB by a 4% margin or 23 missions out of a total 774. 355 missions were flown with optimal distance from Andrews and 378 from Scott and 41 were evenly efficient. The delegation of eight assets should be evenly distributed between the two bases: Andrews AFB and Scott AFB. If nine C-21 assets are considered, five should go to Scott AFB unless there is a large reduction of CVAM or JOSAC missions. The missions flown are largely not repetitive with the exception of the majority of SOUTHCOM flights using the same city-pairs. Using the optimal base to execute missions, results in a ten percent system savings.

V. Conclusions and Recommendations

Chapter Overview

The conclusions drawn are the basing decision of the C-21 assets based on optimum use. Optimum use was defined by improved efficiency, defined by fewer flight hours resulting in a lower cost and an increase in time, and effectiveness, defined by more availability and delivering DVs to their requested destinations. The amount the C-21 flew each type of support mission drove the final ratio of the asset allocation. Future research could use a different spreadsheet technique by analyzing the entire mission versus the individual active legs, to compare the results. The future optimal solution is based on historical data, but to fulfill the objectives of AMC, the strategy and aim for this fleet could be better analyzed.

Conclusions of Research

Multiple conclusions have been derived from this research and the results. Primarily, the ratio of eight aircraft split evenly between Scott AFB and Andrews AFB will optimally utilize the assets based on the historical data of CY14. A majority of the total missions out of Scott AFB are more efficient which drives in the case of an odd number of assets, a majority to Scott AFB. The basing of the eight assets in CY14 evenly between the two bases could have affected the optimal solution. All 774 active legs were compared for minimum distances and no data was thrown out. The determination of number of aircraft at each base was determined by taking the ratio of the minimum missions at each location. There could be a ten percent system savings should a more efficient plan be utilized.

One question remains: do the DV requests drive the missions filled or do the available assets at current bases drive the missions flown?

Significance of Research

The goal of this research was to determine the optimal allocation of the C-21 assets to achieve economic savings for the Air Force and time savings for all the components in the system including the Distinguished Visitors, the C-21 crews and maintenance. The research focused on the CY14 use of C-21s when the allocation of the eight assets assigned was split evenly between Andrews AFB and Scott AFB. The research separated the C-21 mission data into mission types, so that the resulting ratios could be applied if there were a change in the proportion of missions in the future. For example, in 2006 the C-21s at Andrews AFB did not support CVAM or SOUTHCOM missions, but rather, almost solely, JOSAC missions. Therefore, the optimal basing solution would be based on a JOSAC mission only scenario. The mission data was further separated by aircraft origin so that the optimum solution could be compared to actual execution to evaluate cost avoidance and measure performance increases. The optimal solution would have saved 299 flight hours and $213,187 in CY14.

Recommendations for Action

Utilize this spreadsheet model on repetitive missions of an asset such as the C-130. This model is best used for analyzing active legs with cargo to move from different points which form the legs and the city-pairs. Then, the optimization of the assets can be determined by the driving needs of the customer demands. The C-130 fleet, unlike the C-21 fleet is large enough to analyze efficiencies not driven by located assets.

Recommendations for Future Research

To analyze the basing optimization, place an additional asset at Andrews AFB for one year with the appropriate additional manning. The results could support or negate that the ratio of the assets drives which missions are filled. The strategy, the purpose of the C-21 fleet, needs to drive the utilization. If basing is based on efficiency and effectiveness because the overall theme of the Air Force Cost Culture is interpreted as the goal, then by focusing on reducing the budget of eight C-21s at the sub-optimization of the system is flawed, unless the system as a whole has become more value added. Is the priority of the fleet more flight hours to season pilots with a less expensive flight hour saving millions while transporting DVs or is the priority having more assets available at the location that Transportation Command and Air Mobility Command are situated or is the priority the most efficient transport of DVs?

Summary

The eight C-21 assets assigned to support the OSA mission will be optimized by placing four at Scott AFB and four at Andrews AFB. If the OSA mission legs are flown in this manner, the results are improved efficiency, fewer flight hours and lower costs. Availability and effectiveness increases. The amount the C-21 flew each of the three types of support missions drove the final ratio of the asset allocation and this will continue to affect efficiency and optimization. Future research could use a different spreadsheet technique to compare the results, but the assumptions made were limited. Although in many models, the recent history is a good predictor of the future, perhaps a

better way to form the decision of asset allocation is based on the objectives derived from the strategy of the organization.

Appendix A – Fuel Cost Charts and Equations

Aircraft Make/Model	DOCS Estimate	USAF LCF AFI65-503, A4-1	Fuel Cost Per Hour ($3.62)	NBAA IFR Seats Full	Total Acft	Acft Avail	Acft Hours	Range of Sales Prices ($K)
Beechjet 400A (T-1A)	$1,503	$1,351	$688	1519	178	0	9000	N/A
Citation Sovereign	$1,765		$869	2620	341	25	1750	6199-12900
Lear 35 (C-21A)	$1779	$1,777	$713	2306	28	17	16000	N/A
Hawker 800XP	$1905		$941	2470	475	52	4700	1595-4800
Challenger 300	$1,918		$977	3100	398	22	2750	9500-18995
Challenger 604	$2,182		$1,086	3824	368	35	5450	5395-13500
Falcon 900EX	$2,453		$1,021	4500	239	20	5000	12995-26950
Falcon 900B/C	$2,725		$1,068	3400	203	41	8250	4995-12950
G-450	$2,783		$1,625	4100	251	23	1800	19950-34000
Gulfstream IV/SP (C-20H-2 acft)	$2,895	$6,554	$1,665	3880	287	32	6250	6795-15850
GulfstreamV (C37A-9 acft	$3,274	$5,067	$1,636	6250	194	23	4800	15000-21900
GulfstreamIII (C20B-5 acft)	$3,636	$6,554	$1,901	3460	5	0	14000	N/A

Preserving Readiness: A Domestic Channel Solution to Cost-Effective Mobility Pilot Experiencing

Standard Fuel Prices in Dollars
FY 2014 President's Budget
FY 2014 Rates

		Per Gallon	Per Barrel
AVGAS (CONUS)	130	$ 4.13	$ 173.46
AVGAS (OCONUS)	LL	$ 16.21	$ 680.82
Diesel Fuel:			
Distillates	F76	$ 3.61	$ 151.62
High Sulfur	DF1	$ 3.62	$ 152.04
Generic (High Sulfur)	DF2	$ 3.25	$ 136.50
Ultra Low Sulfur	DS1	$ 3.62	$ 152.04
Ultra Low Sulfur	DS2	$ 3.49	$ 146.58
Burner Grade	FS1	$ 3.53	$ 148.26
Burner Grade	FS2	$ 3.11	$ 130.62
Biodiesel	BDI	$ 3.49	$ 146.58
Jet Fuel:			
	JP8 & JA1	$ 3.62	$ 152.04
	JAA	$ 3.60	$ 151.20
	JP5	$ 3.64	$ 152.88
	JTS	$ 6.45	$ 270.90

Standard Fuel Prices in Dollars FY2014 President's Budget FY 2014 Rates

Flight Hour Cost C-17

(Fuel Burn Rate in Lbs/Hr)/(Gallons/Lb))=Gallons/Hr

(21097Lbs/hr) x (1 Gal/6.7Lb) = 3148.81Gal/Hr

(Gallons/Hr)x(Price of JP8/Gallon)=Cost per Hour

(3148.81Gal/Hr) x ($3.62/Gal) = $11398.68/Hr

AFPAM 10-1403

Appendix B – US Air Force Officer Pay Chart

YEARS OF SERVICE	RANK Officers enter as an O-1 (Second Lieutenant) and are subsequently promoted up through the ranks to O-2 (First Lieutenant), O-3 (Captain), etc.									
	O-1 Second Lieutenant	O-2 First Lieutenant	O-3 Captain	O-4 Major	O-5 Lieutenant Colonel	O-6 Colonel	O-7 Brigadier General	O-8 Major General	O-9 Lieutenant General	O-10 General
2 or less	$33,941	$39,103	$45,256	$51,473	$59,656	$71,561	$96,548	$116,197		
Over 2	$35,327	$44,536	$51,304	$59,587	$67,205	$78,620	$101,038	$120,002		
Over 3	$42,703	$51,293	$55,375	$63,562	$71,856	$83,776	$103,111	$122,530		
Over 4	$42,703	$53,024	$60,372	$64,447	$72,734	$83,776	$104,760	$123,235		
Over 6	$42,703	$54,115	$63,263	$68,137	$75,636	$84,096	$107,748	$126,389		
Over 8	$42,703	$54,115	$66,438	$72,094	$77,371	$87,703	$110,700	$131,652		
Over 10	$42,703	$54,115	$68,494	$77,022	$81,191	$88,178	$114,113	$132,880		
Over 12	$42,703	$54,115	$71,867	$80,860	$83,992	$88,178	$117,515	$137,876		
Over 14	$42,703	$54,115	$73,627	$83,527	$87,613	$93,190	$120,928	$139,309		
Over 16	$42,703	$54,115	$73,627	$85,057	$93,157	$102,049	$131,652	$143,618		
Over 18	$42,703	$54,115	$73,627	$85,943	$95,789	$107,251	$140,706	$149,854		
Over 20	$42,703	$54,115	$73,627	$85,943	$98,392	$112,446	$140,706	$155,599	$164,221	$187,765
Over 22	$42,703	$54,115	$73,627	$85,943	$101,354	$115,405	$140,706	$159,437	$166,590	$188,680
Over 24	$42,703	$54,115	$73,627	$85,943	$101,354	$118,400	$140,706	$159,437	$170,006	$192,607
Over 26	$42,703	$54,115	$73,627	$85,943	$101,354	$124,207	$141,422	$159,437	$175,968	$199,440

Benefits- Officer Pay

Appendix C – Quad Chart

C-21 Fleet: Base Optimization

Maj Rebecca Wyffels
Advisor: Darryl K. Ahner, PhD, PE
Advanced Studies of Air Mobility (ENS)
Air Force Institute of Technology

Introduction

This research reveals the optimal use of the C-21 in support of Distinguished Visitor transport of the highest ranking military and civilians in our nation is beneficial in many ways. Optimal basing of assets reduces flight hours resulting in a reduction of spending, an increase in flexibility and a more effective use of time. This research project analyzed over 1000 flights on over 350 missions conducted in 2014. Eight C-21s are currently assigned to the operational support airlift mission, located at Andrews Air Force Base, Maryland and Scott Air Force Base, Illinois. The missions flown from these bases were compared against an optimal solution minimizing travel distance and time to determine the best allocation of the assets supporting the operational support aircraft mission as well as the SOUTHCOM mission. Operating the 2014 mission set optimally, would have resulted in 298 fewer flight hours, a savings of $213,187 and 28 minutes of availability daily.

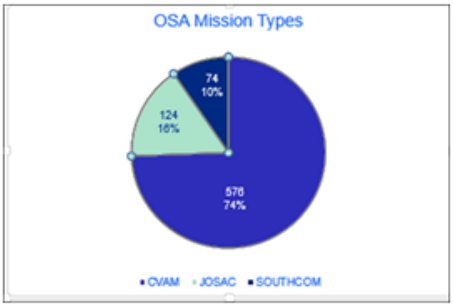
Methodology

The spreadsheet model utilized the supplied data from the 375 OG to organize the origin and destination of each leg of over 350 missions and 1000 flights in 2014. The active legs were the legs that carried a DV as a passenger. These active legs were extracted and listed as city-pairs representing where the DV was picked up and where he was delivered as well as the frequency of use of that city-pair during the year. The data remained filtered into mission type for analysis. This allowed for an overall basing decision as well as basing decisions should the C-21s' proportion of support to each mission change. The positioning legs and de-positioning legs were not utilized in the city-pairs.

The total mission distance in nautical miles from Scott AFB, to the origin of the active leg to the destination of the active leg and back to Scott AFB, was compared to the same roundtrip out of Andrews AFB. The minimum distance travelled when the two bases were compared, determined the optimal solution for each active leg. The ratio of most efficient missions out of a base to the total missions determined the ratio or percentage applied to the eight assets for assignment.

Additionally, the actual use and optimal use of the CY14 missions were compared to determine savings.

	Aircraft	Andrews AFB	Scott AFB	Andrews AFB	Scott AFB
TOTAL	8	4	4	48%	52%
	9	4	5		
CVAM & JOSAC	8	4	4	44%	56%
	9	4	5		
CVAM & SOUTHCOM	8	4	4	51%	49%
	9	5	4		
JOSAC & SOUTHCOM	8	4	4	55%	45%
	9	5	4		



Collaboration

458 A$/C$$

AIR FORCE INSTITUTE of TECHNOLOGY

Research Goals

1. Determine the optimal assignment of C-21s to Scott AFB and Andrews AFB.
2. Determine the impact of the three types of Distinguished Visitor Transport: Joint Operational Support Airlift Center (JOSAC), Office of the Assistant Vice Chief of Staff Special Air Missions (CVAM), and Southern Command (SOUTHCOM); on the overall basing optimization.

Implications

The immediate impact of this research will prevent the Air Force from overspending time and money while conducting the mission of transporting its highest officials.

The logistical impact of this study on the body of knowledge is not limited to same-type fleet issues, but rather, can be applied to the Air Force fleet-wide. The spreadsheet model can take inputs such as various numbers of assets, origins, and city-pairs to optimize basing by minimizing distance travelled.

Conclusions & Recommendations

The eight C-21s currently used for Operational Support Airlift and SOUTHCOM missions should be split evenly between Scott AFB and Andrews AFB. This will optimally utilize the assets based on the historical data of CY14. A slight majority of the total missions are more efficiently flown out of Scott AFB, therefore, if an additional asset is acquired, the majority should be assigned to Scott AFB. A ten percent savings in flight hours could have been realized should the most efficient base have flown the missions last year.

One question remains: do the DV requests drive the missions filled or do the available assets at current bases drive the missions flown?

Glossary

AFB	Air Force Base
AFSO21	Air Force Smart Operations for the 21st Century
AMC	Air Mobility Command
CONUS	Continental United States
CVAM	Office of the Assistant Vice Chief of Staff/Special Air Missions
CY	Calendar Year
FTU	Formal Training Unit
FY	Fiscal Year
JOSAC	Joint Operational Support Airlift Center
NCR	National Capital Region
NM	Nautical Miles
OG	Operations Group
OSA	Operational Support Airlift
SOUTHCOM	Southern Command
SWA	Southwest Asia
TWCF	Transportation Working Capital Fund

Bibliography

AFPAM 10-1403, Table 9, Fuel Burn Rates, HQ AMC/A3XP, December, 2011.

Baker, J. *Optimizing C-17 Pacific Basing*. Wright-Patterson AFB, OH: Air Force Institute of Technology, 2014.

"Benefits- Officer Pay," accessed May, 2015, at http://www.airforce.com/benefits/officer-pay

Clark, B. "Scott AFB to become 'one stop C-21 shop,'" *Air Force Print News Today*, 2011.

Clarke, L. W., Hane, C. A., Johnson, E. L., & Nemhauser, G. L. "Maintenance and Crew Considerations in Fleet Assignment," *Transportation Science*, 30(3), 249-260 (1996).

Dubois, Christopher S., 458th AS/CSS, telephone interview with the USAF Captain, January 2015.

Hammer, M. and Champy, J. *Reengineering the Corporation: A Manifesto for Business Revolution.* New York: Harper, 2001.

Klincewicz, J. G., Luss, H., & Pilcher, M. G. "Fleet Size Planning when Outside Carrier Services Are Available," *Transportation Science*, 24(3): 169 (1990).

Martin, C., Jones, D., & Keskinocak, P. "Optimizing On-Demand Aircraft Schedules for Fractional Aircraft Operators," *Interfaces*, 33(5):22-35 (2003).

Otley, T. "Jet powered," *Business Traveller,* (UK/Europe Edition), 44-46 (2011).

Pimentel, D. (2000). "Private air transportation emerging as key business tool," *Business Journal Serving Fresno & The Central San Joaquin Valley*, 3 (2000).

"Standard Fuel Prices in Dollars FY2014 President's Budget FY 2014 Rates," accessed April, 2015, at http://www.energy.dla.mil/DLA_finance_energy/Documents/FY14_Oct_01_2013_Standard_Prices_V3.pdf

Torczynski, A. *Preserving Readiness: A Domestic Channel Solution to Cost-Effective Mobility Pilot Experiencing.* Scott AFB, IL: Air Force Fellows, Air University, 2014.

"USAF C-21 Fact Sheet," accessed April, 2015, at http://www.af.mil/AboutUs/Factsheets

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
19-06-2015	Graduate Research Paper	May 2014 – June 2015

4. TITLE AND SUBTITLE
C-21 Fleet: Base Optimization

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Wyffels, Rebecca A., Maj

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way, Building 640
WPAFB OH 45433-8865

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT-ENS-GRP-15-J-024

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Col Jeanette M. Voigt
433 Hangar Rd
Scott AFB, IL 62225
618-256-3608 DSN 576 jeanette.voigt@us.af.mil

10. SPONSOR/MONITOR'S ACRONYM(S)
375 OG/CC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A.APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES
This work is declared a work of the U.S. Government and is not subject to copyright protection in the United States.

14. ABSTRACT

This research reveals the optimal use of the C-21 in support of Distinguished Visitor transport of the highest ranking military and civilians in our nation is beneficial in many ways. Optimal basing of assets reduces flight hours resulting in a reduction of spending, an increase in flexibility and a more effective use of time. This research project analyzed over 1000 flights on over 350 missions conducted in 2014. Eight C-21s are currently assigned to the operational support airlift mission, located at Andrews Air Force Base, Maryland and Scott Air Force Base, Illinois. The missions flown from these bases in the last calendar year were compared against an optimal solution minimizing travel distance and time to determine the best allocation of the assets supporting the operational support airlift mission. Based upon the 2014 mission data, and the optimal basing ratio, four assets at both Scott and Andrews AFB is the optimal assignment. If nine total assets were optimized, five would be assigned to Scott AFB and four to Andrews AFB. Operating the 2014 mission set optimally, would have resulted in 299 fewer flight hours, a savings of $213,187 and 23 minutes of availability daily.

15. SUBJECT TERMS
C-21, Basing, Optimization, DV Airlift, OSA

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Darryl K. Ahner, AFIT/ENS
U	U	U	UU	50	19b. TELEPHONE NUMBER *(Include area code)* (937) 255-6565, x 4708 (darryl.ahner@afit.edu)